"Saki-ika": Dried Squid Processing Equipment and Markets

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Introduction

Squid has been widely recognized as an underutilized food fishery in the United States. Only 18,700 t were landed by domestic vessels in U.S. waters during 1978, yet the potential annual yield has been estimated at about 390,000 t (Gulland, 1971). United States fishing efforts for squid usually occur in inshore waters within 19 km (12 miles) of the coast. A small directed fishery exists in California, where 91 percent of the total 1978 domestic catch was landed. Kato and Hardwick (1975) have described the various methods used to capture *Loligo opalescens*, the principal species landed off the U.S. West Coast. In northwest Atlantic waters, most squid landings are incidental to trawl effort for finfishes (Lux et al., 1974). *Loligo pealei* and *Illex illecebrosus* compose most of the catch (Rathjen, 1973).

American consumer demand for squid traditionally has been low, with domestic consumption generally limited to small ethnic markets. Recently, squid has gained some popularity as an entree in California restaurants (Ampola, 1974) and a study designed to assess market potential in New England has been started (Rathjen, 1977). However, neither development has yet had a large impact on consumer patterns. Although a portion of the current catch is canned or frozen for export, primarily to Europe and the Philippines (Ampola, 1974), much of the squid harvested by American vessels is used for bait.

In contrast to American consumer tastes, squid is a popular food in many countries in Europe and the Far East and is growing in demand in Southeast Asia (Hotta, 1976). As the demand for squid has exceeded the available supply from their own waters, many foreign fleets have harvested increasingly large amounts of squid from U.S. waters. Squid landings reported by foreign vessels fishing off the U.S. East Coast exceeded 39,000 t in 1977, compared with only 2,500 t taken by U.S. vessels in that area during the same period (Kolator and Long, 1979). However, U.S. adoption of the 200-mile extended jurisdiction, which went into effect on 1 March 1977, has imposed restrictions of squid landings by foreign vessels. As other countries follow the pattern of restricting foreign landings in their own waters, many of the countries where squid demand is high will increasingly turn to imports (Miller et al., 1974).

As an abundant species underutilized for food in the United States but highly prized and increasingly scarce abroad, squid clearly offers great potential as an export product. In the past, however, two factors have consistently been cited as major obstacles to development of the U.S. squid fishery (Ampola, 1974; NEFDP, 1977). No automated equipment capable of splitting, eviscerating, skinning, and processing the squid into a finished product has been known to be available. The laborious, time-consuming procedure for manually cleaning and preparing squid is not economically practical in the United States. Furthermore, no sizable market for squid products has been developed, despite the potentially large export markets. As a result, dock prices are so low that many fishermen do not deem catching squid to be worthwhile. Obviously, these factors are interdependent: Large-scale market development is severely hampered by the lack of automated equipment capable of processing the volume of squid necessary for substantial market demand.

Automated Processing Equipment

In actuality, automated equipment which performs most of the major steps necessary to process squid into a dried form has been in use in Japan for a number of years. By transforming raw squid into a product ready for the supermarket shelf, this machinery both

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ABSTRACT–Dried and seasoned squid products, in a wide variety of forms, are very popular in Japan. Over 400,000 t of raw squid are processed into these products annually. Traditionally processed by hand and sun-dried, most of the processing and drying can now be accomplished with automated equipment. The manufacturing of "daruma" and "saki-ika" two forms of seasoned, dried squid which are not subject to Japanese import quotas, is described. The potential use of this technology for processing American squid for the large Japanese market is discussed.

eliminates the problems inherent in manual processing and also produces a form of squid that is popular among consumers in a country whose squid imports have increased significantly since 1976—Japan (Iida, 1978).

This paper will describe some of the Japanese dried squid products, the automated processing and drying equipment developed by the Japanese, and potential uses of such equipment in the United States. It will also assess the advantages of exporting seasoned dried squid to Japan, and will suggest possibilities for market development for seasoned dried products in this country.

Japanese Dried Squid Products

Traditionally, squid was eaten in Japan in a sun-dried form called "surume." Although improvements in freezing and cold storage facilities during recent years have made fresh or frozen squid more readily available to Japanese consumers, seasoned and unseasoned dried squid continues to be very popular. In 1977, approximately 400,000 t of raw squid were converted into a variety of dried and seasoned squid products. While the sun-drying method is still used in some rural areas of Japan, it has been virtually replaced by the use of automated equipment, which is not only considerably faster and more efficient but also eliminates the potential for spoilage due to less than ideal weather conditions.

The general procedure for preparing dried squid products consists of splitting and eviscerating the raw squid; removing the ink sac, cartilage, and skin; and drying the mantle, arms, and fins. Depending on the particular type of product desired, the arms and sometimes the fins may be removed and processed separately, seasonings may be added, and the dried squid may be shredded, rolled flat, or shaped. In some products the skin is not removed. Differences in appearance, flavor, texture, and moisture content distinguish the various types of dried squid products.

A number of terms, some with overlapping meanings, are used by the Japanese to describe the different types of dried squid products. "Chimmi," a general Japanese term for any seasoned and prepared seafood product, is combined with "ika," the word for squid, to refer to processed squid products. "Daruma" designates a slightly seasoned, semi-dried intermediary form consisting of skinless mantles with fins, from which various types of "chimmi-ika" are processed.

Popular types of "chimmi-ika" are "surume," "saki-ika," and "noshi-ika." "Surume," previously used to refer to sun-dried squid, now denotes unseasoned dried squid, either whole or with mantle and fins only. "Surume-ika" is also the Japanese name of the particular species, *Todarodes pacificus*, that once constituted up to 90 percent of the Japanese domestic squid catch. (Before the advent of freezers and automated processing equipment, "surume-ika" and "surume" were virtually synonymous and even today are often used interchangeably.) "Noshi-ika" consists of mantles with fins that have been flattened, stretched, and softened by rollers. Seasoned and shredded mantles are referred to as "saki-ika."

"Chimmi-ika" are popular snack foods in Japan and are enjoyed on the same types of occasions as are potato chips or salted peanuts in the United States. Among adults, "chimmi-ika" are particularly favorite accompaniments to sake, beer, and whiskey. Their texture ranges from mild to sweet to spicy; their texture, from crisp to chewy. They usually are packaged in plastic bags and are commonly marketed in stores, restaurants, bars, and vending machines.

Manufacture of "Saki-ika" and "Daruma"

The equipment and procedures used to produce "saki-ika," with "daruma" as an intermediary product, are typical of the automated technology currently used to produce a number of Japanese dried marine products. Some of this equipment can be used in the production of other squid products and, with minor modifications, can also be used to process fish fillets, such as Alaska pollock, which are popular in Japan and other Asian countries.

Either fresh or frozen (whole or split and cleaned) squid can be used as the raw material for this processing. In earlier times, "saki-ika" was traditionally made from "surume." Since this product (called "hard saki-ika") is difficult to chew, almost all of the current production is made from foreign frozen squid. Some imported "daruma" is also being used as the raw material.

The processing procedure is outlined below. A system of net and belt conveyors transfers the squid from one stage of the process to the next in a fully automated plant. In areas where labor is less expensive, some conveyors and machines, such as the splitters and coolers, can be eliminated. As a result, the processing time increases and careful attention must therefore be given to the freshness of the squid during the processing.

The yield and moisture content of the squid during the various processing stages are given in Table 1.

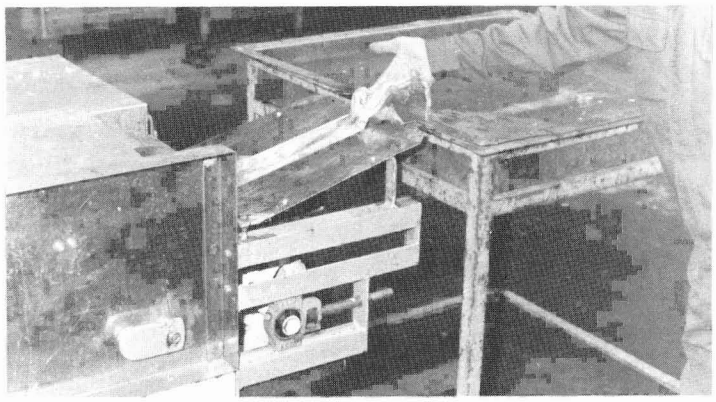
Splitting and Cleaning

This process, known as "hiraki," is generally performed with a squid splitting machine. Raw squid are fed anterior end forward into the machine which splits the mantle and removes the head, entrails, and ink sac (Fig. 1a, b, c). The machine can be set to either remove the arms or leave them attached, depending upon the final product desired. For "daruma" or "saki-ika" the arms are removed, leaving a

Table 1.—Yield and moisture content by process stage for the production of 1,000 kg of saki-ika.

Process stage	Yield (kg)[1]			Avg. moisture content[1]
	Body	Arms	Fins	
Whole raw squid	8,000			82
Split, eviscerated squid (arms removed)	4,340	1,600		
Skinned	3,600	1,040		78
First drying	[2]1,368	392		37-38
Roasting (fins removed)	1,232	360		32
Processed product	[3]1,000	319	160	[4]28
Total yield: 1,479 kg (18.5 percent)				

[1] Average values based on *Todarodes pacificus* caught near Hokkaido.
[2] "Daruma"
[3] "Saki-ika"
[4] ±1 percent.



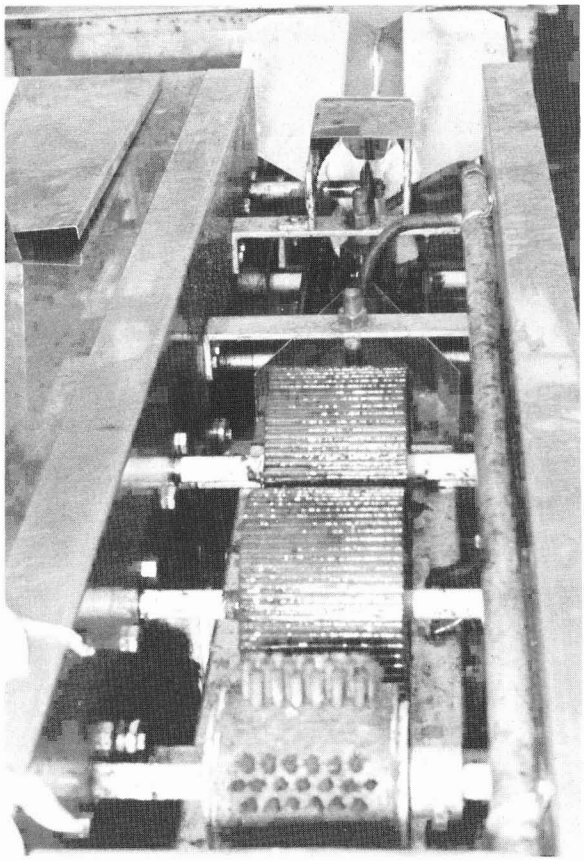


Figure 1.—Squid, at top, are fed into the splitting/cleaning machine. At right is the splitting/cleaning machine showing rotary blade, rollers, and brushes. At bottom are split and cleaned squid (machine was set to leave arms attached).

flat triangular shaped mantle with fins. The quill or pen, where present, is removed manually; this is essential if the end product is to be of the high quality demanded by the Japanese market. A trained operator can process about 3,000 squid per hour.

The entrails are used as fertilizer or bait and the eyes are used in the production of luminous dials. The arms are processed in a similar manner and are packaged and sold separately as "geso."

Washing

Prior to skinning, the squid is washed to ensure that the final product is of high quality. A continuously operating rotary washer with a capacity of 4,500 kg (9,900 pounds) is used. When used with a conveyor system, this process is completely automated.

Skinning

Once they have been washed, the squid are transferred to skinning machines supplied with hot water (Fig. 2). As the hot water blanches the squid, the skin is loosened by the pressure of rapidly circulating water which removes the skin from the flesh without damaging it.

An automatic hot water heater heats the water and regulates its flow to the skinning machine. Water temperature is varied from 50° to 65°C, depending on the freshness of the squid. Selecting the correct temperature is an important factor in product quality. If the water is too hot during the initial stage of the process, spots form on the mantle and the flesh shrinks; if it is tepid near the end of the process, the flesh will become thin when dried, resulting in poor yield. Generally, 50 percent of the water is replaced twice during the operation. When the skinning process is complete, the squid are agitated in the machines in water 70°-80°C for about 3-5 minutes, and then are placed on a net conveyor.

Cooling

Rapid cooling is necessary after the squid are skinned and heated. Rotary cooling machines which spin the squid through air and cool water are generally used. As an alternative, the squid can simply be placed in tanks of cool water (Fig. 3).

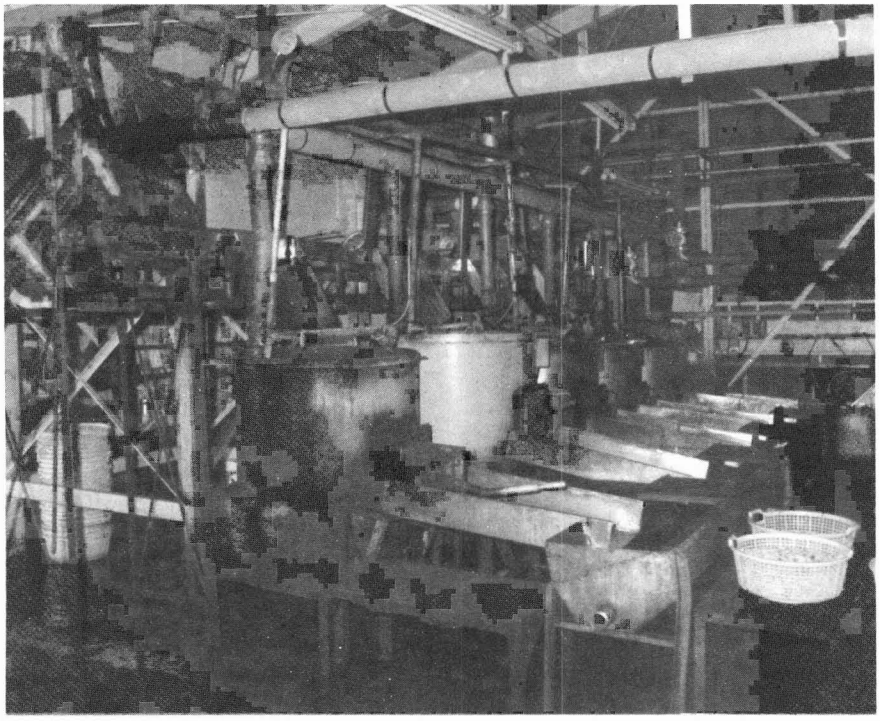


Figure 2.—Squid skinning machines. Squid enter via net conveyor at top and exit via chute at bottom.

Figure 3.—Squid are removed from cooling bath after skinning (press roaster in background)

First Seasoning

The cooled squid is automatically weighed and a proportionate amount of dry powdered seasoning, pre-mixed in a rotary mixer, is added to it via a constant-speed conveyor belt. Although the exact composition of the seasoning varies, it usually includes salt, natural sweeteners, spices, ascorbic acid, sugar, monosodium glutamate, and other flavoring agents.

The squid and seasonings are placed in polyethylene containers for a minimum of 4-6 hours. In actual practice, they usually remain there overnight for convenience. During this time fluids released from the squid mix with the seasonings to form a solution. If room temperature exceeds 25 °C, the squid must be stored in a refrigerated room to prevent a spontaneous fermentation which reduces quality and yield.

First Drying

The squid are drained, placed on nylon mesh racks (Fig. 4), and put in an air drying unit in which a temperature of 40° C is maintained by a fully automated oil burner and air circulation system. After 8-10 hours of drying the moisture content is reduced to about 37-38 percent. This partially processed squid mantle (with fins) is known as "daruma." It can either be marketed at this point to a processor and later processed into other forms, or it can be immediately processed into a finished product such as "saki-ika."

A description of the process necessary to produce "saki-ika" follows.

Press Roasting

The squid ("daruma") is fed into press roasters and pressed for 10-15 minutes between two conveyor operated heated plates. The temperature of the plates, running speed, and roller spacing of these presses can be adjusted to accommodate a wide variety of sizes and species.

Removal of Fins

The fins and top of the mantle are removed manually. They are then processed separately and marketed as "mimi."

Rolling

The mantles are fed into a roller press and flattened (Fig. 5).

Shredding

The flattened mantles are hand-fed into a shredder in which two sets of blades shred the mantle into strips. Usually the strips are about 3 mm (0.12 inch) in width (Fig. 6), but for "ultra saki-ika" the strips are 5 mm (0.2 inch) in width.

Second Seasoning

The shredded mantles are seasoned for a second time in a rotary mixer (Fig. 7). Alcohol diluted with water is sprayed over the squid to liquify the seasoning so that it will soak into the squid. The squid is held in polyethylene containers for 4 hours. Again the particular composition of the seasoning varies according to the desired flavor for the final product.

Second Drying

During the second drying process an infrared drying unit is used to bake in the seasoning which coats the squid with a film that aids in retarding spoilage. The moisture content is reduced to about 28 percent. The product is now "saki-ika" (Fig. 8).

Packaging

Additional seasonings and additives, generally in an ethanol base, may be added to the "saki-ika" during packaging. Salt and active water (potassium sorbate, sodium metaphosphate, and acetic acid) are also added to prevent color changes and to adjust the pH to between 5.9 and 6.0 in order to retard mildew formation. Expected shelf life of "saki-ika" ranges from 60 days to 6 months. The final product is generally packaged in attractive clear plastic bags with the "saki-ika" readily visible to the consumer (Fig. 9).

Discussion

The National Marine Fisheries Service has been evaluating the potential for developing a food fishery for American squid, particularly on the U.S. East Coast, for some time. Studies

Figure 4.—Squid tentacles are placed on drying racks.

Figure 5.—Flattened squid mantles come off roller press.

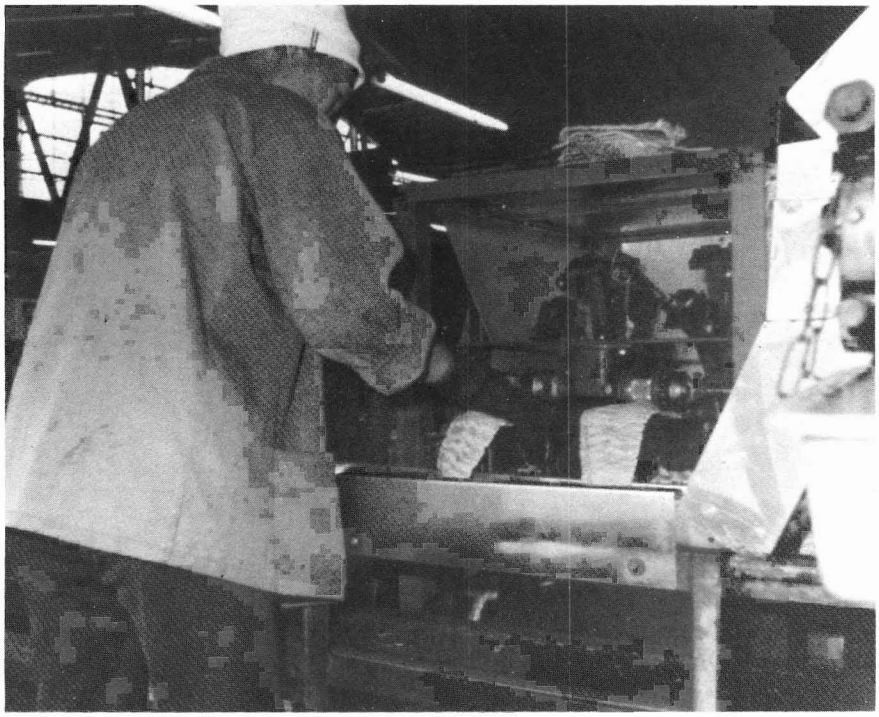


Figure 6.—Squid mantles are fed into shredding machine.

Figure 7.—Seasoning squid for the second time in a rotary mixer.

of the biology and stock status of squid off the northeast coast have been conducted (Lange, 1978; Tibbetts, 1977; Tibbetts-Lange and Sissenwine, 1977), and basic models designed to simulate the effects of fishing on these stocks have been developed (Sissenwine and Tibbetts, 1977). A number of studies have identified squid as a major underutilized resource (Ampola, 1974; Lux et al., 1974; Rathjen, 1977) and one which has considerable potential for export (Miller et al., 1973; McAvoy and Earl, 1977). Recent studies of the care and maintenance of squid quality (Learson and Ampola, 1977) and foreign fishing operations off the East Coast (Kolator and Long, 1979) have provided valuable information about squid fishing practices and proper handling of squid at sea.

Processing dried squid in the United States for export to Japan and other Asian countries offers a number of advantages. Most importantly, it would make possible the development of a U.S. squid fishery on the East Coast. Introduction of the Japanese automated processing technology would address the two major factors most often cited as reasons for the current underdevelopment of this fishery: Lack of processing equipment and lack of a substantial market (NEFDP, 1977). The Japanese technology provides the means to produce squid products which are popular and expensive in Japan.

Approximately 600,000 t of squid are consumed annually in Japan, which has the highest consumption (both per capita and total volume) of squid in the world. About 50 t of dried squid products, including 30 t of "saki-ika," are eaten daily. Faced with declining domestic catches and increasing restrictions on its distant water fisheries, Japan began importing squid in 1976 (Iida, 1978). The total amount of squid imported in 1978 was over 122,000 t, worth about $240 million; this represents a 36 percent increase over the figures for 1977. While the Japanese Government restricts squid imports through a system of import quotas, these quotas have recently been liberalized; "daruma" and "saki-ika," as well as some other processed pro-

ducts are not subject to quota restrictions.

Exporting squid in a dried form offers several specific advantages. The quality of squid required for the production of some forms of dried squid is not as stringent as that for other products. Frozen trawl-caught squid can be effectively used. In addition, shipping costs (a major consideration in exporting) for dried squid products are significantly lower per value unit than for fresh or frozen squid, due to the reduced volume and weight.

Processing squid in the United States would add considerable value to the catch, employ Americans, and contribute to easing the trade deficit with Japan. The recent devaluation of the dollar with respect to the yen has made American products more attractive to Japanese buyers. A new law passed in 1978 amends the 1976 Fishery Management and Conservation Act and gives American companies the first chance to process fish caught in U.S. waters by American fishermen. This has served to increase the cooperative relationships between U.S. and Japanese fishing interests as evidenced by the increase in U.S. seafood exports to Japan (Kaplan, 1979). The use of this processing technology and equipment could assist in bridging the gap between the resource and the buyer, and help eliminate the problem of variations in product quality which has hindered earlier attempts to enter the Japanese market.

A product such as "saki-ika" may also have potential for introduction into the U.S. market as a high protein snack food. The final product does not resemble whole squid and the taste can be adjusted by altering the seasoning. It is somewhat similar in both taste and texture to the popular beef jerky sticks currently available on the U.S. market.

Figure 8.—Shredded and seasoned squid come out of the infrared dryer and are bulk packaged.

Figure 9.—Final packaged product among a variety of dried products at a wholesale market.

Acknowledgments

The authors wish to express their appreciation to Shigeo Iwase and Koji Takasugi of Taiyo Seisakusho Mfg. Co., Ltd. for providing information on the processing procedures and equipment, and reviewing the manuscript. Thanks are also extended to Yoshio

Tanaka of Asahi Shokuhin Co., Ltd. and Efren Ed. C. Flores of Hokkaido University for their assistance during tours of the processing plant. We are also indebted to Cornelius K. Iida, NMFS International Fisheries Affairs, Warren F. Rathjen, NMFS Gloucester Laboratory, and James H. Johnson, Regional Fisheries Attaché-Tokyo, for their generous help in providing additional information and statistical data. Travel support for this study was provided through a grant to the senior author from the Japan Society for the Promotion of Science.

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